

**ROCKY FLATS BUILDING NO. 71**  
**PLUTONIUM FIRE ANALYSIS**

**PART I**

**FINAL REPORT**

**FOR**

**MJP RISK ASSESSMENT, INC.**  
**IDAHO FALLS, IDAHO**

**PREPARED BY**

**DILIBERTO + ASSOCIATES, Inc.**  
**M. C. DILIBERTO, P.E.**

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6860 S. Yosemite Ct., Suite 200  
Englewood, Colorado 80112  
(303) 399-4100

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## EXECUTIVE SUMMARY

### A. INTENT OF REPORT

This Report has been developed to determine and identify the factors contributing to the fire and explosion in Building 71 at the Rocky Flats Plant that occurred in September 1957. Specifically, the report addresses three aspects of the fire: (1) fire development, spread and its severity within the plenum filters; (2) cause(s) of filter failure (during the fire leading up to and after the explosion); and (3) cause(s) and location of the explosion that occurred within the building's Main Exhaust System plenum. This explosion was the result of the Room 180 Conveyor glovebox fire which started on the evening of September 11, 1957. The resultant explosion caused gross plutonium (Pu) contamination throughout Building 71 and discharge to the atmosphere through the stack located downstream of the building's Main Exhaust System fans.

### B. FINDINGS

The following factors are proposed as the primary contributing factors to the **fire** involving the Cambridge CWS-6 "Absolute" paper filters and the subsequent **explosion**. These and additional Findings are covered in more detail in Section III.

These conclusions are based on: (1) an analysis of the Original Rocky Flats Fire Reports; (2) review of design standards, recommendations and guides involving nuclear and industrial facilities handling hazardous materials in place at that time; (3) review of other related publications associated with plutonium and combustible filters originally used at this facility; and (4) employing sound fire protection engineering principles.

#### **! Factors Contributing to the Fire Development**

1. Improper storage of plutonium skull (massive metallic casting residues) in an open container.
2. Failure to remove and store in an inert container alpha phase plutonium (skulls, and other production residue; i.e., **turnings/chips mixed with cutting oil to form an "oil sludge" mixture**) that was subject to oxidation within the glovebox and store in an inert container during non-production/operational times.
3. Inadequate humidity and moisture control of air in area handling plutonium.
4. Original unfamiliarity with alpha phase plutonium. In addition, Building 71 was not designed to handle this phase of plutonium but rather a specific quantity of delta plutonium.

5. Lack of understanding of fire exposure risks involving materials used in the construction of the gloveboxes (i.e., Plexiglas) and material handled within the gloveboxes.
6. Heavy use of combustible Plexiglas for glovebox: (1) structural enclosures; (2) partitions separating adjacent gloveboxes; and (3) as view panels.

**! Factors Contributing to the Fire Spread and Severity**

Nine factors are listed in the Original Rocky Flats Fire Report dated October 1957, as contributing to the fire — specifically the fire spread and severity. These factors are concurred with and are restated in Section II which follows. However, the following *additional* factors are believed to have also contributed to the fire spread which resulted in the explosion.

Note: All these factors have been addressed since the fire spread/severity was the catalyst for the explosion.

1. Non-compliance with: (a) latest recognized National Fire Protection Association (NFPA) Ventilation, Exhaust and related fire protection system Design Guides, Codes and Standards; and (b) recommendations addressed in Atomic Energy Commission (AEC) published papers relating to Nuclear Air Cleaning System design and general fire protection requirements for facilities handling plutonium in effect at the time Building 71 was being designed/constructed.
2. Little or no implementation of updated NFPA/AEC recommended procedures, or retrofitting of equipment/design features to improve operations from a safety/fire protection standpoint was performed in spite of the special hazards (both health and fire) associated with operations in Building 71.
3. No automatic sprinkler protection in: (a) Room 180 and associated gloveboxes; (b) Glovebox Booster Exhaust Systems' ductwork and associated filters; and (c) the building's Main Exhaust System filter plenum.
4. No automatic fire detection system provided on the downstream ("clear air") side of the Glovebox Booster Exhaust System filters.
5. No fire hose standpipes in the stairwell entrances of the building's Main Exhaust System Plenum Area.
6. No fire dampers in the exhaust ducts where they terminate at the Main Exhaust Plenum wall.
7. Neither non-combustible nor fire resistant partitions between adjacent gloveboxes.
8. Decision to continue to use the combustible CWS-6 filters with heavy loadings of combustible dust (6-10 lbs./filter) in lieu of cleaning/replacing them. The

majority of the approximately 620 filters were in continuous service over four years.

9. Switching the building's four Main Exhaust System fans to high speed approximately 15 minutes after the fire was first discovered.
10. Management's lack of an effective fire fighting plan for the facility.
11. Inadequate operating instructions and procedures regarding: (a) housekeeping; (b) inspection and cleaning of exhaust system ductwork/filters; (c) to a lesser degree the storage of flammable material in the building's Main Exhaust System Plenum; and (d) fire fighting procedures for the hazards located in Room 180.

**! Fire Development/Spread Theory — Sequece of Events Time Line: From Estimated Start of Room 180 Glovebox Fire Through Explosion**

The analysis performed in this Report helped to establish a more detailed time line than that offered in the Original and Supplementary Rocky Flats Fire Reports issued in October and December of 1957, respectively. This analysis was able to be performed due to the availability of filter fire test results that were obtained during the tests conducted on CWS-6 filters at the Hanford, WA, site in 1953 and at Rocky Flats immediately after the fire and in 1959-1960. The filter burn through times and flame spread rates (with air flows similar to those occurring at the time the fire was discovered and up to the explosion), documented during these tests, provided the basis in establishing realistic fire development//flame spread times from the start of the fire through the explosion.

**! Factors Contributing to the Explosion and Contamination**

Note: Some of these factors also contributed to the fire spread and severity.

1. No automatic sprinkler protection in the Main Exhaust Filter Plenum.
2. Deactivation of the fire detection system in the downstream ("clean air") side of the plenum, and no automatic fire detection system on the downstream ("clear air") side of the Glovebox Booster Exhaust System filters.
3. No fire dampers in the Main Exhaust Plenum wall where the exhaust ducts terminate.
4. Inadequate maintenance/housekeeping resulting in excessive dust loading in the filters.
5. Continued use of combustible CWS-6 filters in lieu of the recently-developed and less combustible HEPA filters.

## **! Explosion Development Theories**

The Original Rocky Flats Fire Reports offered two theories on the cause of the explosion. While they offered some plausibility, it is believed each explosion theory did not involve sufficient amounts of combustible material or flammable gas to produce the explosive force necessary to (a) knock over personnel inside Room 180 where the fire originated and in the adjacent corridor, and (b) to generate the dispersal of Pu dust throughout Building 71 and through the exhaust stack to the atmosphere.

Based on analysis of the reports, papers, articles, Codes, Standards, and records of telephone conversations as referenced in this Report, and applying sound fire protection engineering principles and analysis, a better substantiated Primary Explosion Theory has been developed. This theory along with the two explosion theories referenced above are addressed in more detail in Section III.

### **Primary Explosion Theory**

The author of this current report agrees with the initial fire development and fire spread theory that is described in the original Rocky Flats Fire Report. The fire spread from the Room 180 Glovebox Booster Exhaust System filters to Building 71's Main Exhaust System Plenum where hot gases and burning embers ignited combustible filters and lint that had collected on the face of the filters. As the flames burned across the face of the filter(s), hot gases and flames were pulled further into the paper filter media along with smoke and carbon monoxide (CO), a product of incomplete combustion, due to the four exhaust fans operating at "high speed" (approximately 15 minutes after the fire was discovered). It is postulated that as the smoke particles from the burning filters were drawn further into the filter media, they plugged the unburned portion of the filter preventing CO from exiting. CO then began to "pocket" and build up. Once the flame front reached the pocketed CO, it then ignited the CO resulting in a small "flame flashback" that exited the front side of the filter.

The "flame flashbacks": (1) dislodged into suspension smoldering/unburned lint/dust located on the surface of the filter(s) producing the flashback as the flame and pressure front exited the filter(s); and (2) produced vibrations along the filter bank framework that resulted in the release into suspension of large quantities of surface collected combustible lint/dust and dust collected inside the filters into the upstream ("dirty air") side of the plenum. Ultimately, an explosive concentration of CO developed and was simultaneously ignited along with the suspended lint/dust by one or more occurring "flame flashbacks," and exploded. After the explosion, the contaminated smoke and dust followed the path of least resistance from the filter plenum area. This path included the Main Exhaust system ductwork back into the rooms and corridors of Building 71. In addition, contaminated smoke and dust were discharged through openings in the burned-through and ruptured plenum filters through the main exhaust stack to the outside air. Contaminated smoke continued to be discharged from the stack through natural draft until the plenum filter fire was completely extinguished about 13 hours after the fire was discovered in Room 180. (See Exhibits I and

V, Section V, for the exhaust system layout and fire area and “Flame Flashback Phenomenon of CWS-6 Filters,” respectively.)

**I    Theoretical Calculations of the Explosion**

Calculations have been provided to explain and substantiate the explosion development involving CO and combustible lint/dust. This information is contained in Section IV.

\*\*\* END OF SECTION I \*\*\*